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COVER — A reconstruction of the terrain at the Port Kennedy, Pennsylvania, sinkhole that preserved a Late Irvingtonian fauna and flora. (See the paper by Daeschler, Spamer, and Parris in this volume.) Rendered by Bruce Mohn, Copyright © Bruce Mohn.

The Delaware Valley Paleontological Society thanks the Department of Malacology, Academy of Natural Sciences of Philadelphia, for the facilities to produce the camera-ready pages of this volume. Page composition by Earle Spamer.

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Further Examination of the Woodbury and Basal Englishtown Formations in Camden County and Adjacent Areas, New Jersey

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ABSTRACT — Fourteen outcrops of the Woodbury and basal Englishtown Formations are discussed (see locality map). Some of these were revealed by construction, and are now buried or under water. In the discussion of these localities, this paper seeks to 1) document the fauna and general stratigraphy of previously unreported exposures of the Woodbury and basal Englishtown Formations, 2) add more detail to descriptions of previously reported exposures, 3) document the appearance of the basal Englishtown Formation and the Woodbury-Englishtown transition in this region, and 4) corroborate the occurrence (at many localities in this region) of an abundance of vertebrate remains (mainly shark teeth) occurring at and near the transition.

Introduction

Permanent outcrops in the New Jersey coastal plain tend to occur in stream banks. There are four major streams flowing through the region covered by this study. These are, from northeast to southwest, the Rancocas River, Pennsauken Creek, Cooper River, and Big Timber Creek. These all lie within Burlington, Camden, and Gloucester Counties. Burlington County is adjacent to Camden County to the north and east, and Gloucester County lies adjacent to Camden County to the south and west. These counties all border the Delaware River and form a large part of New Jersey's inner coastal plain. The Rancocas River drains a large part of Burlington County. The Pennsauken Creek drains a comparatively much smaller region to the southwest, draining a small part of both Camden and Burlington Counties. Further southwest, the Cooper River drains a large part of northern Camden County. The Big Timber Creek drainage area, the southern boundary of this report, lies on the boundary between Camden and Gloucester County and drains parts of both. These streams all flow to the northwest into the Delaware River (see Fig. 1). Fossiliferous outcrops in the drainage patterns of these creeks range from the early Campanian Merchantville Formation through the Miocene Kirkwood Formation.

Most of the following sites are located on private property, therefore anyone interested in visiting them must have the permission of the landowner first. In addition, at some localities slumping is commonplace, and one should exercise caution and common sense when working there.

Haddonfield

The classic Haddonfield locality is located near the corner of Maple Avenue and Grove Street in Haddonfield, New Jersey. Here, outcrops are in the stream banks of a tributary of the Cooper River. The Woodbury Formation is exposed here as a dark, micaceous, greasy clay, flecked with many shell fragments; it underlies Pleistocene(?) gravels. On first inspection the preservation of shells in this clay seems so poor as to quickly discourage collection. This explains why material from this locality is seldom collected. However, several trips to the site indicated that much better specimens can be obtained with perseverance. In fact, many of the specimens are surprisingly well preserved. The fossils at the site are preserved as original shell material, except near the boundary with the Pleistocene(?) gravel, where groundwater has leached most of the shell material away, leaving steinkerns and external molds.

While collecting the site, the writer found the formation to be very homogenous, in both lithology and paleontology. The only exception to this is that, at some places, there is a bed almost entirely composed of the pelecypod *Gervilliopsis ensiformis*.

At the Haddonfield locality, some of the species found are diminutive, compared to those same species found at other New Jersey localities in the Woodbury Formation. Richards et al. (1958) recognized this, and in his description of the pelecypod species *Yoldia papyria* he states:

> The types of this species from Haddonfield are scarcely more than one-half the size of the specimens whose dimensions are given above. This fact, however, is in accord with the individuals of many of the Haddonfield species, which grow to a much larger size in the more northern localities.

Also, when describing the pelecypod species *Volsella julia*, he describes the type specimen from Haddonfield as being

> . . . just one-half the size of the larger individual figured in the present report from Lorillard. This fact is in agreement, however, with nearly all the species which are common to these two localities, the Lorillard individuals generally being much larger than those from Haddonfield.

Although Richards et al. (1958) applied these statements just to more northerly Woodbury outcrops, such as the Lorillard and Matawan localities, a few species found at Haddonfield are diminutive compared to those from other New Jersey upper Cretaceous formations: *Exogyra costata* Say, *E. c.* var. *spinifera* Stephenson, *Exogrya ponderosa* var. *erraticostata* Stephenson, *Pecten* (*Neithea*) *quinquecostata* Sowerby, and *Veniella conradi* Morton.

The following faunal list combines species reported by Weller (cf. Richards et al., 1958, 1962) and those found by the writer. Some of the species found by the writer represent new occurrences at this locality, and some are new records for the Woodbury Formation. Species the writer found are labelled A, C or UC. These symbols refer to the relative

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Key to Localities

1. Haddonfield
2. Pennypacker Park
3. Maple Avenue
4. Cambridge Crossing
5. Barclay Farms
6. Deptford Pit
7. Little Timber Creek
8. Creek Road
9. Cooper Landing Road
10. Tindale Run
11. Cooper River Drive
12. Sewage disposal locality
13. Cedar Avenue
14. Marlkress Road

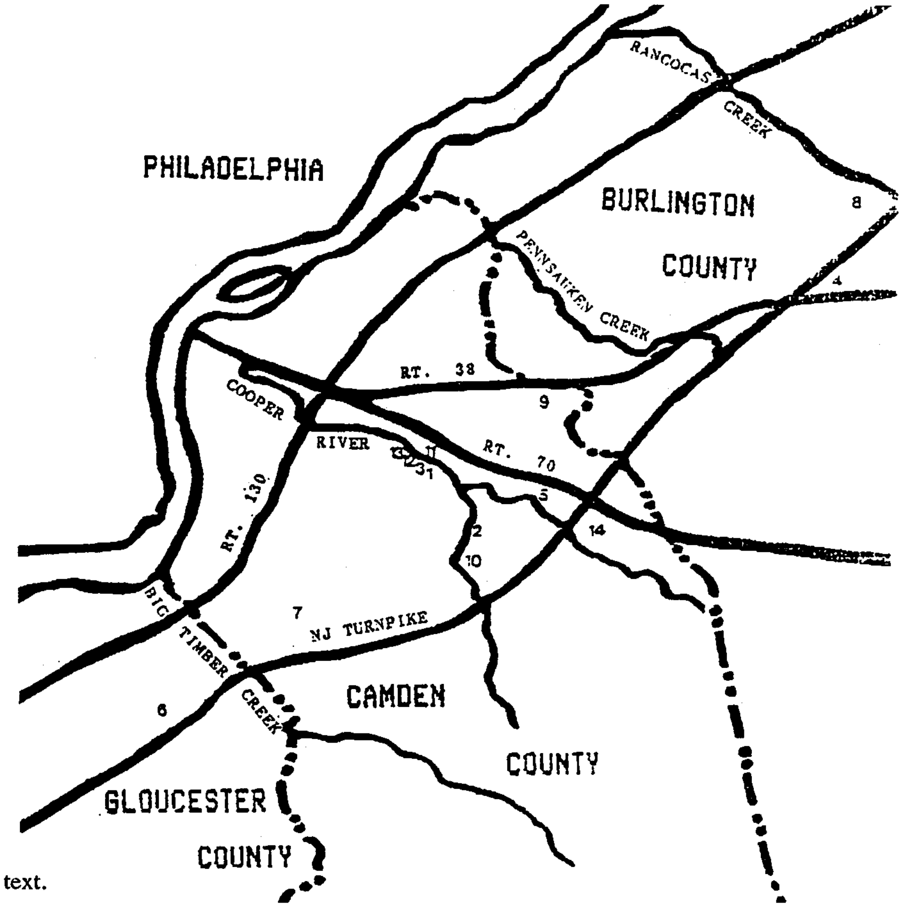


Figure 1. Map of localities mentioned in text.

abundance of the species, as estimated by the writer. Species lacking one of these symbols were reported by Weller, but not found by the writer. Species labelled "A" (abundant) were collectable at a rate of at least 25 specimens per collecting day. Species labelled "C" (common) were collectable at a rate of between 5 and 25 specimens per day. Species labelled "UC" (uncommon) were collectable at a rate of less than 5 specimens per day. Vertebrate findings include two very small teleost fish vertebrae and two small turtle bone fragments.

INVERTEBRATA

Coelenterata

Astrangia (Coenangia) cretacea (Bolsche)	A
Micrabacia cribraria Stephenson	
Trochocyathus woolmani Voughan	UC

Annelida

Hamulus squamosus Gabb	UC
Longitubus lineatus (Weller)	UC

Brachiopoda

Lingula subspatulata Hall and Meek

Pelecypoda

Aenona eufaulensis (Conrad)	UC
Aenona papyria Conrad	
Aenona sp.	UC
Agerostrea mesenterica Morton	UC
Amphidonte sp.	UC
Anatimya anteradiata Conrad	UC
Anomia argentaria Morton	C
Antgona (Aphrodinia) cretacea (Conrad)	
Antgona (Aphrodinia) tippana [*jerseyensis*] Richards	C
Breviarca haddonfieldensis Stephenson	C
Breviarca umbonata (Conrad)	
Breviarca sp.	UC
Camptonectes bellisculptus (Conrad)	C
Camptonectes burlingtonensis (Gabb)	
Cardium lorillardensis Weller	
Cardium ripleyanum Conrad	UC
Cardium stantoni Wade	UC
Cardium tenuistriatum Whitfield	C
Corbula bisulcata Conrad	
Corbula crassaplica Gabb	A
Corbula foulkei Lea	C
Corbula lorillardensis Weller	
Corbula swedesboroensis Weller	
Crassatella sp.	UC
Crassatellites hodgei Stephenson	
Crassatellites linteus (Conrad)	UC
Crassotrea tecticosta (Gabb)	UC
Cucullaea antrosa Morton	
Cucullaea sp.	UC
Cuneolus sp.	UC
Cymbophora lintea (Conrad)	UC
Cymbophora sp.	UC
Cymella bella [*texana*] Stephenson	UC
Cyprimaria depressa Conrad	C
Cyprimaria welleri Stephenson	
Eriphyla decemnaria (Conrad)	
Eriphyla declivis (Conrad)	
Exogyra costata Say	UC

Exogyra costata var. *spinifera* Stephenson	UC
Exogyra ponderosa var. *erraticostata* Stephenson	UC
Gervilliopsis ensiformis (Conrad)	A
Granocardium dumosum (Conrad)	C
Inoceramus proximus Tuomey	C
Inopera carolinensis Conrad	UC
Isocardia sp.	UC
Legumen concentricum Stephenson	C
Leptosolen biplicata (Conrad)	C
Lima reticulata Lyell and Forbes	C
Linearia metastriata Conrad	C
Linearia ornatissima Weller	UC
Liopistha protexta (Conrad)	UC
Liroscapha squamosa Conrad	
Nemoarca cretacea Conrad	
Nemodon conradi Johnson	
Nemodon cf. *eufaulensis* (Gabb)	UC
Nemodon sp.	UC
Nucula percrassa Conrad	C
Nucula slackiana (Gabb)	
Nucula whitfieldi Weller	
Nuculana compressifrons Whitfield	
Nuculana longifrons (Conrad)	UC
Nuculana pinniformis (Gabb)	
Nuculana stephensoni Richards	UC
Nuculana whitfieldi Gardner	C
Ostrea plumosa Morton	UC
Panopea decisa Conrad	UC
Pecten conradi (Whitfield)	C
Pecten (Neithea) quinquecostata Sowerby	UC
Pecten simplicius Conrad	
Pholadomya occidentalis Morton	UC
Pinna laqueata Conrad	C
Pteria petrosa (Conrad)	UC
Scambula perplana Conrad	
Solyma lineolatus Conrad	
Striarca congesta (Conrad)	
Tellina sp. 1	C
Tellina sp. 2	UC
Tellinimera eborea (Conrad)	
Tenea parilis (Conrad)	UC
Tenea pinguis (Conrad)	UC
Trachycardium eufaulensis (Conrad)	C
Trigonarca cuneiformis Conrad	UC
Trigonia eufaulensis Gabb	C
Uddenia conradi (Whitfield)	
Veniella [*etea*] *carolinensis* var. *aspera* Stephenson	UC
Veniella conradi Morton	UC
Vetericardia crenalirata (Conrad)	A
Volsella julia (Lea)	UC
Volsella sp.	UC
Xylophagella irregularis (Gabb)	UC
Yoldia papyria (Conrad)	UC

Gastropoda

Amauropsis meekana Whitfield	
Anchura rostrata (Gabb)	
Anchura sp.	UC
Arrhoges [*latiala*] *lobata* (Wade)	UC
Avellana costata (Johnson)	UC
Bellefusus sp.	UC
Cancellaria smocki Weller	UC
Caveola subalta (Conrad)	UC
Deussenia sp.	UC
Euspira halli (Gabb)	C
Euthria? fragilis Whitfield	
Fasciolaria? obliquicostata Gabb	
Fususimilus sp.	UC
Graciliala sp.	UC
Gryodes supraplicatus (Conrad)	UC
Hercorhyncus sp.	UC
Laxispira lumbricalis Gabb	UC
Leiostraca cretacea (Conrad)	
Liopeplum rhulei Richards	UC
Morea sp.	UC
Napulus sp.	UC
Obeliscus conellus Whitfield	
Ornopsis sp.	UC
Pugnellus sp.	
Pyropsis sp.	UC
Romera flexicostata Sohl	UC
Turritella encrinoides Morton	
Turritella granulicosta Gabb	
Turritella lenolensis Weller	
Turritella lorillardensis Weller	UC
Turritella quadrilira Johnson	UC
Turritella trilira Conrad	UC

Scaphopoda

Cadulus obnutus Conrad	
Dentalium inornatum Wade	
Dentalium subarcuatum Conrad	C

Cephalopoda

Baculites ovatus Say	UC
Discoscaphites sp.	UC
Placenticeras placenta (DeKay)	C
Scaphites hippocrepis (DeKay)	UC

Echinoidea

spines (gen. et sp. indet.)

Crustacea

Hoploparia gabbi Pilsbry	UC
Protocallianassa mortoni (Pilsbry)	UC

VERTEBRATA

Osteichthyes

small teleost fish vertebra (gen. et sp. indet.)	UC

Chelonia

Toxochelyinae, cf. *Dollochylys* sp.

Ornithischia

Hadrosaurus foulkii Leidy

FLORA

carbonized wood	UC

One interesting notation is the similarities of this fauna to parts of the Black Creek Formation in North Carolina, as noted by Stephenson (1923), Richard et al. (1958, 1962), and Owens and Sohl (1989). The Woodbury Formation is recognized by Owens and Minard (1970) as correlative to only a small part of the Black Creek Formation.

Pennypacker Park

This site is located along a tributary of the Cooper River which flows under Caldwell Road in Cherry Hill. The exposure lies just downstream from the bridge, and is within the boundary of Pennypacker Park, hence named herein as the

Pennypacker Park locality. This site, which is close to the Haddonfield locale, is interesting because it yields a more prolific vertebrate fauna (mostly shark teeth). There was no collecting bias, as similar screening procedures were used at both sites. In addition to an abundant vertebrate fauna, the biostratigraphy of the Woodbury at the Pennypacker site also is different from that of Haddonfield. Unlike Haddonfield, the shells at the Pennypacker locality are restricted, for the most part, to a thin, discontinuous 6- to 12-inch-thick layer. Here, most of the vertebrate remains occur. The shells in this layer are densely packed, and this, along with the limited spacial extent of the locality, limited the number of invertebrate species and specimens collected.

The Woodbury above and below the shell layer is the typical massive, micaceous, greasy clay, lacking shell fragments. A section of sand and gravel (Pleistocene?) overlies the Woodbury here. The writer proposes that the Pennypacker site contains more vertebrate remains because it is higher stratigraphically in the Woodbury section (nearer the Englishtown contact) where abundant vertebrate remains have been known to occur. An example of a Kwb-Ket transitional locale, which contained abundant vertebrate remains, was the Mount Laurel, NJ (Cambridge Crossing) site that will be discussed later.

The Pennypacker and Cambridge Crossing localities are similar in that at both locales there is a 6- to 12-inch-thick layer containing most of the vertebrate remains. This layer is composed of typical Woodbury clay, mixed with a varying amount of greensand, as well as toroidal siderite concretions. Similarly, at both sites, above and below this layer, there is no greensand and the Woodbury assumes its usual black, greasy, micaceous-flecked appearance.

Small pockets of greensand were also observed at the Haddonfield locality associated with areas of unusually high shell fragment concentrations. Minor amounts of greensand are not unusual in the Woodbury Formation as noted by (Owens and Minard 1962). These places may have been areas of high-energy wave action.

INVERTEBRATA

Coelenterata

Micrabacia cribraria Stephenson

Annelida

Hamulus squamosus Gabb

Pelecypoda

Breviarca haddonfieldensis Stephenson
Cardium sp.
Corbula foulkei Lea
Cyprimeria depressa Conrad
Etea delawarensis (Gabb)
Glycymeris sp.
Lucina glebula Conrad
Nucula percrassa Conrad
Veniella conradi Morton

Gastropoda

Turritella sp.

Cephalopoda

Placenticeras placenta (DeKay)

VERTEBRATA

Chondrichthyes

Ischyrhiza mira Leidy (rostral teeth)
Plicatolamna arcuata (Woodward)
Scapanorhynchus texanus (Roemer)
Squalicorax sp.
ray vertebrae (gen. et sp. indet.)
shark vertebra (gen. et sp. indet.)

Osteichthyes

Enchodus ferox Leidy (isolated teeth and one jaw segment)
teleost fish vertebrae (gen. et sp. indet.)

Reptilia

crocodile teeth (gen. et sp. indet.)
turtle bone fragments (Gen et. spec. indet.)

FLORA

carbonized wood fragments

Maple Avenue

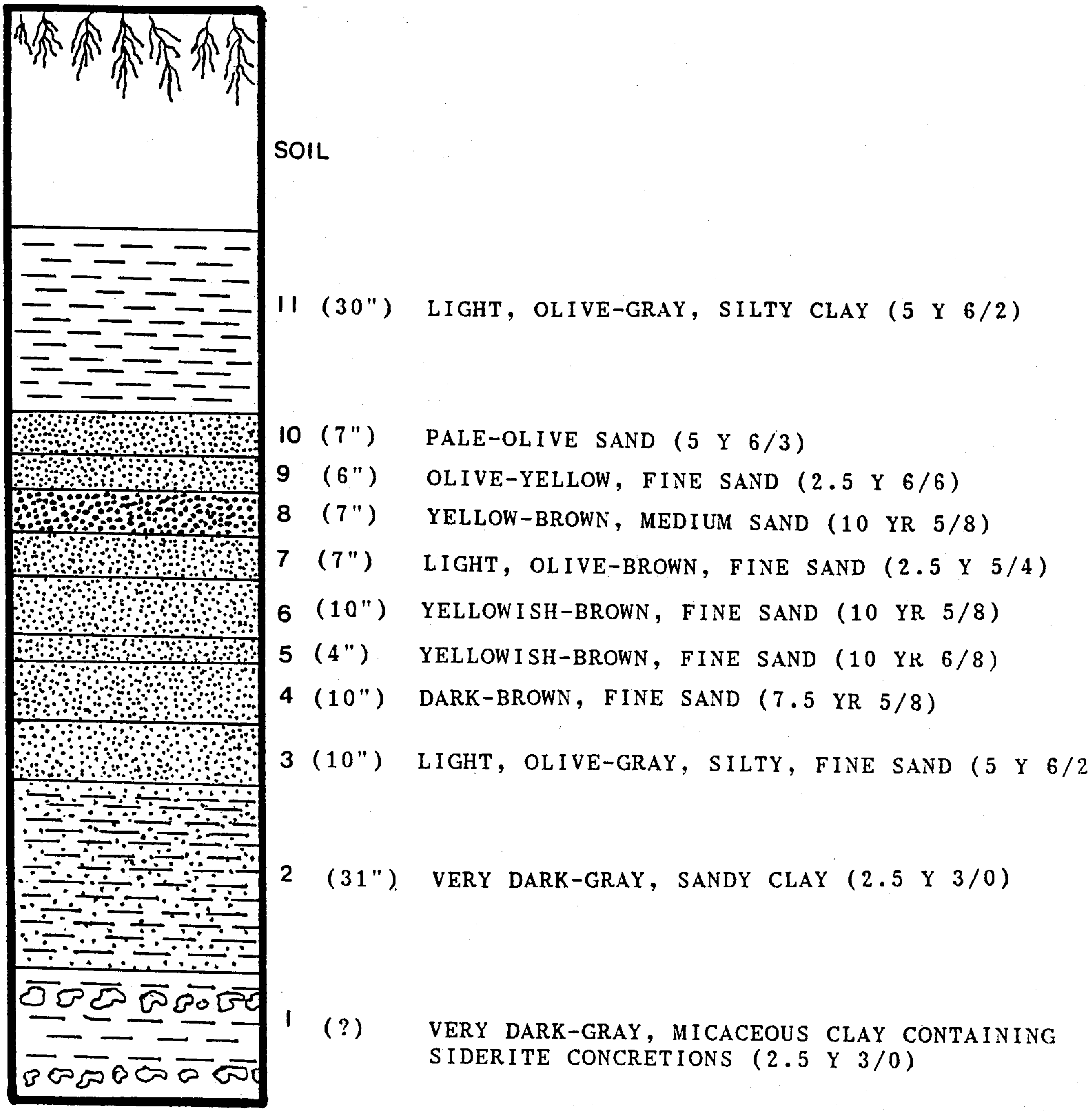
During a sewer excavation in the late 1970s, on Maple Avenue immediately adjacent to the Haddonfield locality, a weathered greensand-clay mix was observed (D. Clements, personal communication). This excavation extended five to six feet below the road level, and the same lithology was observed throughout. The greensand in this exposure appeared to be glauconitic as opposed to the light-green stained, quartz sand that was noted by Gilmore (1990) when describing the stratigraphy at the Cambridge Crossing locality, discussed later.

This glauconitic formation, occurring stratigraphically not far above the Woodbury Formation in the stream bed, most likely was that of the Marshalltown, hence the Englishtown here must be very thin (if it exists at all). If the Englishtown does exist at this locality, the reason why it is not exposed is probably because it is for the most part a loosely held and fine-grained sand, outcrops of which tend to slump and readily erode away. Owens and Minard (1962), when describing the middle and upper parts of the Englishtown, wrote, "Outcrops of the rest of the strata are few because their decreased amount of clay causes them to slump readily."

Cambridge Crossing

This site was previously described by Clements and Gilmore (1987), Bonfiglio (1987), Clements (1990), and Gilmore (1990).

The site consisted of two water retention basins dug in a small stream bed adjacent to buildings in the Cambridge Crossing office complex in Mount Laurel, N.J. The stream is now culverted between the two basins, but it still flows into the larger basin and away from the smaller one. Fossils were collected as the basins were being dug, as well as after they were graded. These excavations were active during 1986 and 1987. These pits have now been sodded over and are therefore inaccessible to collectors. Fossils were also collected from the adjacent flattened spoil pile. This pile is composed of clay and sand dug from the pits. The more productive vertebrate fossil layers were near the bottom of the larger pit, hence these more fossiliferous diggings are now


SOIL
11 (30") LIGHT, OLIVE-GRAY, SILTY CLAY (5 Y 6/2)
10 (7") PALE-OLIVE SAND (5 Y 6/3)
9 (6") OLIVE-YELLOW, FINE SAND (2.5 Y 6/6)
8 (7") YELLOW-BROWN, MEDIUM SAND (10 YR 5/8)
7 (7") LIGHT, OLIVE-BROWN, FINE SAND (2.5 Y 5/4)
6 (10") YELLOWISH-BROWN, FINE SAND (10 YR 5/8)
5 (4") YELLOWISH-BROWN, FINE SAND (10 YR 6/8)
4 (10") DARK-BROWN, FINE SAND (7.5 YR 5/8)
3 (10") LIGHT, OLIVE-GRAY, SILTY, FINE SAND (5 Y 6/2
2 (31") VERY DARK-GRAY, SANDY CLAY (2.5 Y 3/0)
1 (?) VERY DARK-GRAY, MICACEOUS CLAY CONTAINING SIDERITE CONCRETIONS (2.5 Y 3/0)

(adapted from Bonfiglio et. al. (1987))

Figure 2. Stratigraphic section in the lower Englishtown Formation, temporarily exposed during excavations at the Cambridge Crossing industrial complex, Mount Laurel, New Jersey.

buried at the bottom of the spoil pile. However, occasional fossils can still be collected.

Most of the *in situ* vertebrate material came from two light-green colored, quartz sand lentils that cropped out near the bottom of the larger pit (see Fig. 2). When this sand was placed in water, its green hue (due perhaps to glauconite staining) was removed, and the sand was left white or grayish (N. Gilmore, personal communication). As described by Gilmore (1990), the lower and thicker lentil varied between (12-18 inches). Another lentil occurred about three or four feet higher in the pit, and varied 6-12 inches in thickness. This latter lentil contained much clay mixed with the quartz sand, whereas the thicker lentil was pure sand.

Invertebrate remains also were collected, mostly from siderite concretions found in two separate levels of the pit. The majority of concretions occurred in a prominent layer, high in the section. Concretions occurring in this layer were large, being from 3-8 inches in diameter, and generally were spheroidal to elliptical in shape. A few also occurred in the green-colored quartz sand bed low in the pit. Concretions examined from this latter bed were much smaller, less fossiliferous, and mostly toroidal in shape. Occasionally, fossils were found on the outside of these concretions, but the better specimens (preserved as steinkerns, external casts, and molds) were recovered from inside the concretions. In addition, an occasional shark tooth also was preserved in a concretion.

In describing the lithology that occurred at this site, definition of the phrase "Kwb-ket transition" is especially important. Herein, the Kwb-Ket transition refers to those parts of these two formations which 1) are gradational or 2) alternate one with the other; the terminology is taken from geological map symbols. The transition is defined as beginning when the normally black, plastic Woodbury first becomes increasingly sandy higher up in the formation. The transition ends when the massive quartz sand exposures of the Englishtown are reached. The lowermost part of this gradation probably can be called the actual Kwb-Ket contact. However, in many localities this gradation is not exposed, or is vague, hence positioning of the actual Kwb-Ket contact is difficult.

The vertebrate layers examined at this site most likely lie on the Kwb-Ket transition. However, it has also been suggested that this site exposed the basal part of the Marshalltown Formation. The proposal that this site exposes the Kwb-Ket transition will be examined first.

Owens and Sohl (1969), in describing the Woodbury, state that

> Throughout most of its outcrop area, the Woodbury is a massive monotonous dark-gray, micaceous clayey silt. Locally thin lentils of glauconite sand are associated with the large discoidal gray siderite concretions in the upper part of the formation.

This description of the upper Woodbury accurately describes the lithology observed at the Cambridge Crossing locale. Owens and Minard (1962) described the upper Woodbury by saying:

> In the upper 10 feet of the formation there is a recurrence of very fine-grained quartz and medium-grained, pale-green (5 G 7/2), glauconite sand, although clay is still the dominant constituent.

and

> Near the top of the formation numerous thin partings of very fine-grained quartz sand are interbedded with the clayey bed.

They also described the Kwb-Ket transitional beds:

> The Woodbury through an interval of about 10 feet is transitional with the overlying Englishtown Formation. The thin sand partings in the upper beds of the Woodbury increase in thickness and number until quartz sand becomes dominant over clay. Light-gray to light-brown concretions, generally rounded to ellipsoidal and consisting of finely crystalline intergrowths of siderite and quartz, occur in discontinuous layers in this interval.

And they described the basal Englishtown:

> The basal beds of the formation are medium-gray (N 5) clay quartz sand that contains numerous discontinuous lenses of the previously described siderite-bearing concretions.

These descriptions also accurately describe the lithology and stratigraphy examined at Cambridge Crossing. Good exposures of fine, gray-yellowish quartz sands were observed at the top of the smaller pit and in the stream bed, upstream from the larger pit. For another description of the lower Englishtown stratigraphy at Cambridge Crossing, readers are referred to Clements and Gilmore (1987).

The alternative explanation is that the exposure at the site were of the basal Marshalltown. If this is the explanation, then when the pit was dug, the extensive sands, typical of the middle and upper part of the Englishtown Formation, should have been found in the lower part of the pit. This was not the case, however, as the bed of sand of typical Englishtown appearance occurred only high up in the smaller pit and in the banks of the stream, upstream from the larger basin.

Secondly, the appearance of the exposure was not like that of the basal Marshalltown Formation observed at nearby localities. Owens and Minard (1962) describe the basal Marshalltown as "a dark gray-black (N 2) to dark-gray (N 3), micaceous, fine-grained quartz glauconite sandy clay to clayey sand." This was not observed at the Cambridge Crossing locality. For the aforementioned reasons, the writer feels that the Cambridge Crossing locality exposed the Kwb-Ket transition.

Gilmore (1990) described the vertebrate remains found at this site, and generally compared that part of the fauna to that described by Robb (1989) from Phoebus Landing, North Carolina. The following is an invertebrate faunal list for the Cambridge Crossing locality, updated from Bonfiglio (1987).

Coelenterata

Trochocyathus sp.

Annelida

Hamulus falcatus (Conrad)
Longitubus lineatus (Weller)

Brachiopoda

Lingula subspatulata Hall and Meek

Pelecypoda

Aenona sp.
Anatina? sp.
Anomia argentaria Morton
Antgona (Aphrodinia) sp.
Breviarca sp.
Camponectes bellisculptus (Conrad)
Cardium sp.
Cardium tenuistriatum Whitfield
Corbula bisulcata Conrad
Crassatellites vadosus (Morton)
Cymella bella (texana) Stephenson
Eriphyla sp.
Ethmocardium welleri Stephenson
Gryphaeostrea vomer (Morton)
Inoceramus proximus Toumey
Inoceramus sp.
Inoperna carolinensis Conrad
Kummelia americana (Gabb)
Leptosolen biplicata (Conrad)
Linearia metastriata Conrad
Nemodon angulatum (Gabb)
Nemodon brevifrons Conrad
Nemodon cf. *eufaulensis* (Gabb)
Nucula percrassa Conrad
Nucula sp.
Ostrea sp.
Panopea sp.
Pholadomya roemeri Whitfield
Pinna laqueata Conrad
Pteria petrosa (Conrad)
Pyncnodonte? sp.
Solyma lineolatus Conrad
Tellina sp.
Tenea parilis (Conrad)
Tenea pinguis (Conrad)
Trachycardium longstreeti Weller
Veniella conradi Morton

Gastropoda

Anchura sp.
Anisomyon borealis (Morton)
Bellifusus sp.
Euspira halli (Gabb)
Gyrodes sp.
Odontofusus sp.
Pugnellus sp.
Pyropsis reileyi Whitfield
Turritella trilira Conrad
Volutomorpha sp.

Cephalopoda

Baculites sp.
Placenticeras placenta (DeKay)
Smedaliceras sp.

Echinoidea

Hardouinia florealis (Morton)

Crustacea

Ophiomorpha nodosa Lundgren
Tetracarcinus subquadratus Weller

Ichnofauna

crab coprolites?

This fauna has a notable absence of the various *Exogyra* species and a dearth of *Ostrea* species, both of which are common in the New Jersey Cretaceous formations younger than the Englishtown Formation, where a shell bed is present. In this respect the fauna closely resembles that of the Woodbury. For example, the writer has only four specimens of *Exogyra* from Haddonfield, and Richards et al. (1958) reported a dearth from that locality. One *Ostrea* specimen was found at Cambridge Crossing, but this was larger and quite different from the common New Jersey species.

Barclay Farms

Gallagher (1984) provided a complete description of this locality, and the opportunity is taken here to update the faunal list.

The Barclay Farms locality offers another exposure of the Woodbury Formation in the valley of the Cooper River. The Woodbury here consists of a silty, weathered clay. This site is unusual in that many vertebrate remains (mainly shark teeth) are found in the stream bed, but few are found in the formation itself. The writer agrees with Gallagher (1984) that the majority of teeth were washed from upstream. This probably occurred before the stream was culverted. No evidence suggests that the stream started further away than the property adjoining the culvert, where a depression occurs in the yard. Thus, any layer containing an abundance of teeth can be only a short distance, horizontally and vertically, from the present exposures. The presence of some shark teeth in the formation here, as reported by (D. Clements, personal communication), may also indicate the proximity of a richer vertebrate layer.

The teeth found at this locality are preserved like those from the Pennypacker site, being for the most part dark-green and well worn. The invertebrates at this site are preserved as steinkerns, external casts, and molds.

INVERTEBRATA

Annelida

Hamulus sp.

Pelecypoda

fragmentary steinkerns (gen. et sp. indet.)

Gastropoda

Anchura sp.
Lunatia sp.
Turritella sp.

Crustacea

Hoploparia sp.

Cephalopoda

Placenticeras placenta (DeKay)

VERTEBRATA

Chondrichthyes

Plicatolamna arcuata (Woodward)
Scapanorhynchus texanus (Roemer)
Sqalicorax sp.

Osteichthyes

Enchodus ferox Leidy
teleost fish vertebrae (gen. et sp. indet.)

Reptilia

Chelonia limb bone (gen. et sp. indet.)
Mosasaurus sp. (one small tooth)

Deptford Pit

A description and faunal list was reported by Clements and Gilmore (1987). Further description was added by D. Clements (personal communication.)

This site is located on Deptford Avenue just south of its intersection with Delsea Drive in Deptford Township. This pit, now filled with water, was dug for clay which was used at an Atlantic County landfill. A few fossils can still be found on the surrounding spoil piles. This site once again demonstrates a proliferation of vertebrate remains near the Kwb-Ket transition. In addition to abundant vertebrate fossils, this site also contained a well-preserved molluscan assemblage, very similar to that observed at the Haddonfield site.

The lithology at this site consisted of typical Woodbury clay which gradually became sandier towards the top of the pit. This probably represents the lowermost Kwb-Ket transition. The sandy clay, near the top of the pit, contained marcasite concretions. Another feature at this site was the presence of several green-colored, quartz sand lentils, similar to the ones that occurred at the Cambridge Crossing locality. These were located above the level where the Woodbury started becoming sandier. Many turtle remains were collected from one of these lentils. Most of the vertebrate specimens were found throughout the lowermost part of the transition, and a few were also found in the clay below.

Little Timber Creek

This site is along the banks of Little Timber Creek, just upstream from where that creek flows under the Black Horse Pike exit of Interstate 295, between Haddon Heights and Bellmawr. This locale represents another Woodbury shell bed outcrop. The shells here are also preserved as original shell material. Overlying the Woodbury at this site are sands and gravel (Pleistocene?) which in places are cemented by iron oxide, forming an ironstone ledge. The fossil shells in this exposure, and the lithology of the formation, appear to be identical to that of the Haddonfield locality.

Creek Road

D. Clements and B. Hutchinson (personal communications) augmented the writer's knowledge of this locality.

This site consisted of two large clay pits on the grounds of a golf course under construction in the summer of 1990. This course is located on and extends west from Creek Road in Moorestown, immediately north of Parker's Creek, a large tributary of the Rancocas River. The clay pits were in the Woodbury Formation, which was being dug for landfill use. At least 50 vertical feet of Woodbury Formation was exposed in the larger pit, located nearer to Creek Road. This section probably represented most of the Woodbury. Near the top of this pit black, plastic clay graded into a gray, sandy clay. This sandy clay contained marcasite nodules. This gradation probably represented the lowermost Kwb-Ket transition, as did the gradation observed in the Deptford pit. The only fossils found in the larger pit were two *Placenticeras* specimens and several crab fragments. The crab material was found in scattered concretions near the base of the pit.

The smaller pit, the one further from Creek Road, was mostly backfilled when examined. On the backfill, *Scapanorhynchus* and *Squalicorax* teeth were collected, along with a few poorly preserved invertebrate steinkerns. The writer feels that the vertebrate specimens were derived from the Kwb-Ket transitional beds in this pit. The absence of invertebrates preserved as original shell material, in either pit, was notable.

Cooper Landing

This site lies along a northward-flowing tributary of the south branch of the Pennsauken Creek. This tributary begins near the corner of Chapel Avenue and Cooper Landing Road in Cherry Hill. The Woodbury is well exposed along this stream; however, no fossils were found along the stream's entire length. In the fall of 1990 a few fossils were found in an area adjacent to the stream, a few hundred feet from the road intersection. Here, fossil invertebrates were found in cores, probably left over from percolation tests. Only one end of the sample cores contained fossils, which were preserved as original shell material. This, along with the lack of fossils in the stream bed, probably indicates that the shells found in the cores came from a level below the stream bed. Since the clay was not sandy, and since no quartz sand lentils, quartz pebble, or siderite concretion layers were observed (common features of the upper Woodbury in the study area), the stratigraphic section of the Woodbury here is probably well below the Englishtown.

Tindale Run

This site is located on a tributary of the Cooper River which flows under Haddonfield-Berlin Road (Route 561) about 1/2 mile south of where that road crosses the river. The most prominent exposure is located on the south side of Tindale Run about 100 feet downstream from the road. Here, ten to fifteen vertical feet of Marshalltown Formation crops out in the bank. The Marshalltown here appears as a medium greensand, with brownish streaks throughout (probably due to weathering). Although the Marshalltown contains no fossils at this outcrop, D. Clements (personal communication) reports that original shell material was observed on construction heaps, when the houses adjacent to the stream were built.

Downstream from this outcrop typical Woodbury clay occurs on both stream banks. Here, the Woodbury locally contains abundant clay molds and casts of invertebrates, but in most places is relatively nonfossiliferous. The upper part of the section contains increasing quantities of quartz sand and pebbles. The writer found a single, rootless shark tooth in this part of the outcrop. Unfortunately, the Kwb-Ket and Ket-Kmt (Englishtown-Marshalltown) contacts are not found, because of slumping. It is interesting to note how similar this section is to that at the Haddonfield and former Maple Avenue localities, where the Marshalltown occurs above the Woodbury, but no Englishtown is exposed.

Cooper River Drive

This locality is along a small tributary of the Cooper River which crosses Cooper River Drive about 1/2 mile southeast of where that road intersects Grove Street. This tributary flows under Wayne Avenue in the Erlton section of Cherry Hill. Small exposures of Woodbury occur near Wayne Avenue. Here, a loose concentration of invertebrates, preserved as original shell material, is found.

Cooper River Sewage Disposal Locality

This locality occurs along a very small tributary to the Cooper River, and is immediately north of the classic Haddonfield locality. The outcrop is reached by parking at the end of Beechwood Avenue, which intersects Grove Street and is one street north of Maple Avenue, and proceeding north for a few hundred feet until a small gully is reached, on the far side of the old sewage disposal facility. The tributary begins at the head of the gully, at the outflow of the pipeline.

The formation at this site contains a loose concentration of original shelled invertebrates, however many of the specimens are more or less flattened. Judging from the topography of the area, this site represents a lower stratigraphical section of the Woodbury, in relation to the nearby classic locale.

Cedar Avenue

This site lies along a small tributary of the Cooper River which flows north from Farwood Avenue, just west of its intersection with Cedar Avenue, in Haddonfield. Here, the upper part of the Woodbury is exposed. The bank and stream bed at the headwaters of this tributary expose a clayey sand, rich in mica flakes and small quartz granules, but with few fossils. These sediments may represent the basal Englishtown. Further downstream, exposures are of massive clay, typical of the Woodbury. In these exposures casts and molds of invertebrates are found.

Marlkress Road

This locality is located on a tributary of the north branch of the Cooper River which flows under Marlkress Road in Cherry Hill, about 1/2 mile south of that road's intersection with Route 70. Good exposures of the black, micaceous, sandy clay (Woodbury Formation?) occur in the stream banks east and west of the road. Even with such a long section exposed, no fossils were found.

Near the headwaters of this stream, the formation underlies a bed of fine quartz sand containing possible burrows in its lower part. Higher in the section the formation is composed of small quartz pebbles, which in some places are stained light-green.

Conclusion

As demonstrated, the Woodbury invertebrate fauna is large and varied. If the faunal lists contained in this paper were added to occurrences at old Woodbury outcrops, most of which are detailed by Richards et al. (1958), the result would be a faunal list larger than that for any other single New Jersey Upper Cretaceous formation. The Merchantville Formation invertebrate fauna is also very large, and the writer finds little difference between that fauna and that of the Woodbury. The small differences that do exist can probably be attributed to preservational differences, as no original shell material is found in the Merchantville. Undoubtedly, a number of redundant species names were assigned as a result of the different preservation occurring in these two formations. The writer hopes that correlation of Merchantville and Woodbury specimens may someday clear up some of these idiosyncrasies.

Weller (1907) believed the Woodbury fauna to be a *Lucina* (shallow water) assemblage, as opposed to the Merchantville, which he considered a *Cucullaea* (deeper water) assemblage. The writer did not find this to be the case—his collection contains seven *Cucullaea* specimens and only one *Lucina* specimen from the Haddonfield locality. Richards et al. (1958) reported *Cucullaea woodburyensis* Weller and *Cucullaea neglecta* Gabb from the Woodbury.

The writer has only two other *Lucina* specimens from the Woodbury. These came from the Pennypacker and Sewage Disposal localities. The remarks of Richards et al. (1958) also indicates a dearth of New Jersey *Lucina* specimens from the Woodbury. This, along with the writer's findings, indicates that the Woodbury can by no means be called a *Lucina* assemblage, as opposed to a *Cucullaea* assemblage. If anything, the opposite is true. One can not use the lack of *Lucina* specimens from the Merchantville formation of New Jersey as evidence, given their scarcity in the Woodbury, which is more conducive to their preservation. Perhaps future collecting will shed some light on this.

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